We claim:

1. A proton-conducting membrane, comprising a carbon-containing compound and inorganic acid, wherein

a phase-separated structure contains a carbon-containing phase containing at least 80% by volume of the carbon-containing compound and inorganic phase containing at least 80% by volume of the inorganic acid, the inorganic phase forming the continuous ion-conducting paths.

2. The proton-conducting membrane according to Claim 1, wherein said phase-separated structure is a sea-island structure with the carbon-containing phase as the island and inorganic phase as the sea.

3. The proton-conducting membrane according to Claim 1, wherein said phase-separated structure is composed of a carbon-containing phase and inorganic acid phase both in the form of continuous structure.

4. The proton-conducting membrane according to one of Claims 1 to 3, comprising a three-dimensionally crosslinked silicon-oxygen structure (A), carbon-containing compound (B) bound to (A) via a covalent bond, and inorganic acid (C).

5. The proton-conducting membrane according to Claim 4, wherein said carbon-containing compound (B) has a skeleton section substituted with hydrogen at

a joint with the three-dimensionally crosslinked silicon-oxygen structure (A), satisfying the following relationship:

$(\delta p^2 + \delta h^2)^{1/2} \leq 7(\mathrm{MPa})^{1/2}$

wherein, δp and δh are polarity and hydrogen bond components of the three-component solubility parameter.

6. The proton-conducting membrane according to Claim 5, wherein said carbon-containing compound (B) is bound to the three-dimensionally crosslinked silicon-oxygen structure (A) via 2 or more bonds.

7. The proton-conducting membrane according to Claim 6, wherein the skeleton section of said carbon-containing compound (B) is a hydrocarbon consisting of carbon and hydrogen.

8. The proton-conducting membrane according to Claim 7, wherein the skeleton section of said carbon-containing compound (B) has the structure represented by the following formula (1):

$$-\!\left(\mathrm{CH_2}\right)_n\!- \qquad \cdots (1)$$

wherein, "n" is an integer of 2 to 20.

9. The proton-conducting membrane according to Claim 7, wherein the skeleton section of said carbon-containing compound (B) has the structure represented by the following formula (2):

$$-CH_2CH_2\left(C_6H_4\right)_n CH_2CH_2- \qquad \cdots (2)$$

wherein, "n" is a natural number of 4 or less.

10. The proton-conducting membrane according to Claim 6, wherein the skeleton section of said carbon-containing compound (B) has the structure represented by the following formula (3):

$$-O-\left(\underset{\displaystyle R^2}{\underset{|}{\overset{\displaystyle R^1}{\overset{|}{Si}}}}O\right)_l- \qquad \cdots (3)$$

wherein, R^1 and R^2 are each a group selected from the group consisting of CH_3, C_2H_5 and C_6H_5; and "l" is an integer of 2 to 20.

11. The proton-conducting membrane according to Claim 4, wherein said inorganic acid (C) is a heteropoly acid.

12. The proton-conducting membrane according to Claim 11, wherein said heteropoly acid is used in the form of being supported beforehand by fine particles of a metallic oxide.

13. The proton-conducting membrane according to Claim 11 or 12, wherein said heteropoly acid is a compound selected from the group consisting of tungstophosphoric, molybdophosphoric and tungstosilicic acid.

14. The proton-conducting membrane of according to Claim 4, which contains 10 to 300 parts by weight of the inorganic acid (C) per 100 parts by weight of the three-dimensionally crosslinked silicon-oxygen structure (A) and carbon-containing compound (B) totaled.

15. A method for producing the proton-conducting membrane of one of Claims 1 to 14, comprising steps of preparing a mixture of a carbon-containing compound (D) having one or more hydrolyzable silyl groups and said inorganic acid (C), forming the above mixture into a film, and hydrolyzing/condensing the hydrolyzable silyl group contained in the mixture formed into the film, to form said three-dimensionally crosslinked silicon-oxygen structure (A).

16. The method according to Claim 15 for producing the proton-conducting membrane, wherein the skeleton section of said carbon-containing compound having

one or more hydrolyzable silyl groups (D) whose hydrolyzable silyl group(s) are substituted by hydrogen satisfies the following relationship:

$(\delta p^2 + \delta h^2)^{1/2} \leq 7(\mathrm{MPa})^{1/2}$

wherein, δp and δh are the polarity and hydrogen bond components of the three-component solubility parameter.

17. The method according to Claim 16 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups has 2 hydrolyzable groups.

18. The method according to Claim 17 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups is represented by the following formula (4):

$$\left(R^3\right)_{3-m} X_m Si — R^4 — Si X_m \left(R^3\right)_{3-m} \quad \cdots (4)$$

wherein, R^3 is a group selected from the group consisting of CH_3, C_2H_5 and C_6H_5; R^4 is a hydrocarbon compound consisting of carbon and hydrogen; X is a group selected from the group consisting of Cl, OCH_3, OC_2H_5 and OC_6H_5; and "m" is a natural number of 3 or less.

19. The method according to Claim 18 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups is represented by the following formula (5):

$$\left(R^{3}\right)_{3-m}X_{m}Si\left(CH_{2}\right)_{n}SiX_{m}\left(R^{3}\right)_{3-m} \quad \cdots (5)$$

wherein, R^3 is a group selected from the group consisting of CH_3, C_2H_5 and C_6H_5; X is a group selected from the group consisting of Cl, OCH_3, OC_2H_5 and OC_6H_5; "m" is a natural number of 3 or less; and "n" is an integer of 2 to 20.

20. The method according to Claim 18 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups is represented by the following formula (6):

$$\left(R^{3}\right)_{3-m}X_{m}Si-CH_{2}CH_{2}\left(C_{6}H_{4}\right)_{n}CH_{2}CH_{2}-SiX_{m}\left(R^{3}\right)_{3-m} \quad \cdots (6)$$

wherein, R^3 is a group selected from the group consisting of CH_3, C_2H_5 and C_6H_5; X is a group selected from the group consisting of Cl, OCH_3, OC_2H_5 and OC_6H_5; "m" is a natural number of 3 or less; and "n" is a natural number of 4 or less.

21. The method according to Claim 17 for producing the proton-conducting membrane, wherein said carbon-containing compound (D) having one or more hydrolyzable silyl groups is represented by the following formula (7):

$$\left(R^{3}\right)_{3-m} X_{m} Si - O - \left(\begin{array}{c} R^{1} \\ | \\ SiO \\ | \\ R^{2} \end{array} \right)_{l} - SiX_{m} \left(R^{3}\right)_{3-m} \qquad \cdots (7)$$

wherein, R^1, R^2 and R^3 are each a group selected from the group consisting of CH_3, C_2H_5 and C_6H_5; X is a group selected from the group consisting of Cl, OCH_3, OC_2H_5 and OC_6H_5; "m" is a natural number of 3 or less; and "l" is an integer of 2 to 20.

22. The method according to Claim 15 for producing the proton-conducting membrane, wherein said step of hydrolyzing/condensing the hydrolyzable silyl group to form said three-dimensionally crosslinked silicon-oxygen structure (A) uses water (E) to be contained in said mixture.

23. The method according to Claim 15 for producing the proton-conducting membrane, wherein said step of hydrolyzing/condensing the hydrolyzable silyl group to form said three-dimensionally crosslinked silicon-oxygen structure (A) is effected at 5 to 40°C for 2 hours or more.

24. The method according to Claim 15 for producing the proton-conducting membrane, wherein said step of hydrolyzing/condensing the hydrolyzable silyl group to form said three-dimensionally crosslinked silicon-oxygen structure (A) is followed by an aging step effected at 100 to 300°C.

25. The method according to Claim 15 for producing the proton-conducting membrane, wherein said step of hydrolyzing/condensing the hydrolyzable silyl group to form said three-dimensionally crosslinked silicon-oxygen structure (A) is followed by a step in which a compound (F) having a hydrolysable silyl group is spread and hydrolyzed/condensed, effected at least once.

26. A fuel cell which incorporates the proton-conducting membrane according to one of Claims 1 to 14.